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The scattering of laser light from a single diffuser and from a cascade of two diffusers is analyzed with particular emphasis on remote sensing. It is shown that diffuser surface properties and the spacing between diffuser planes can be determined remotely. Conceptually, one measures the angular distribution of the radiation pattern or the decorrelation of the far-zone speckle pattern with respect to changes in the wavelength or the angle of incidence of an input plane wave.

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8. SCIENTIFIC PERSONNEL SUPPORTED BY THIS PROJECT AND DEGREES AWARDED DURING THIS REPORTING PERIOD:

   Lyle Shirley, Ph.D., UR - 1988

   (now working on remote sensing and ballistic missile decoy discrimination at the MIT Lincoln Laboratories)

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88 12

LASER SPECKLE FROM THIN AND CASCADED DIFFUSERS

by

Lyle Gordon Shirley

Submitted in Partial Fulfillment

of the

Requirements for the Degree

DOCTOR OF PHILOSOPHY

Supervised by Professor Nicholas George

The Institute of Optics

University of Rochester

Rochester, New York

ABSTRACT

The scattering of laser light from a single diffuser and from a cascade of two diffusers is analyzed with particular emphasis on remote sensing. It is shown that diffuser surface properties and the spacing between diffuser planes can be determined remotely. Conceptually, one measures the angular distribution of the radiation pattern or the decorrelation of the far-zone speckle pattern with respect to changes in the wavelength or the angle of incidence of an input plane wave.

Models for the transmission of light through single diffusers are presented that contain a dependence on the angle of illumination. The validity of a simplified transmission function for single diffusers that does not depend on angle is examined, and it is found that the simple transmission function is adequate for treating the individual diffusers in a cascade. This is important, since the simpler transmission function leads to manageable overall expressions for the cascade.

A general expression is derived for the two-state correlation function of far-zone complex amplitude from a cascade of two diffusers, where the two states are the initial and final values of the wavelength, angle of incidence, angle of observation, and spacing. This function is then related to the two-state correlation function of intensity, which is a measure of the correlation between the initial and final speckle patterns. The two-state correlation function of intensity is evaluated for various double diffuser combinations.

The effect of surface height models on the radiation pattern is studied. Of particular interest are strong diffusers that have a normally distributed height profile and whose surface height autocorrelation functions are paraboloidal or conical for small spatial offsets. Excellent agreement is obtained between theoretical radiation patterns calculated with conical and paraboloidal autocorrelation functions and experimental radiation patterns measured from ground-glass and acid-etched diffusers, respectively.